Document made available under the Patent Cooperation Treaty (PCT)

International application number: PCT/EP05/002263

International filing date: 01 March 2005 (01.03.2005)

Document type: Certified copy of priority document

Document details: Country/Office: US
Number: 60/549,512
Filing date: 02 March 2004 (02.03.2004)

Date of receipt at the International Bureau: 28 April 2005 (28.04.2005)

Remark: Priority document submitted or transmitted to the International Bureau in compliance with Rule 17.1(a) or (b)

PCT/EP2005/002263

EPO - DG 1

20. 04. 2005

(42)

PA 1291663

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APPLICATION NUMBER: *60/549,512*
FILING DATE: *March 02, 2004*

By Authority of the
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PTO/SB/16 (08-03)
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22651 U.S. PTO

22264 U.S. PTO 60/549512 030204

PROVISIONAL APPLICATION FOR PATENT COVER SHEET

This is a request for filing a PROVISIONAL APPLICATION FOR PATENT under 37 CFR 1.53(c).

Express Mail Label No. EV 414834685

INVENTOR(S)

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Additional inventors are being named on the ________ *separately numbered sheets attached hereto*

TITLE OF THE INVENTION (500 characters max)

METHODS FOR COATING LENSES

Direct all correspondence to: **CORRESPONDENCE ADDRESS**

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ENCLOSED APPLICATION PARTS *(check all that apply)*

☑ Specification *Number of Pages* 27

☑ Drawing(s) *Number of Sheets* 3

☐ Application Date Sheet. See 37 CFR 1.76

☐ CD(s), Number ________

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METHOD OF PAYMENT OF FILING FEES FOR THIS PROVISIONAL APPLICATION FOR PATENT

☐ Applicant claims small entity status. See 37 CFR 1.27.

☑ A check or money order is enclosed to cover the filing fees.

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The invention was made by an agency of the United States Government or under a contract with an agency of the United States Government.

☐ No.

☐ Yes, the name of the U.S. Government agency and the Government contract number are: ________

Respectfully submitted,

SIGNATURE ________

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Date March 2, 2004

REGISTRATION NO. 37,259
(if appropriate)
Docket Number: ESOA:009USP1

USE ONLY FOR FILING A PROVISIONAL APPLICATION FOR PATENT

PATENT

ESOA:009USP1

UNITED STATES PROVISIONAL PATENT APPLICATION

for

METHODS FOR COATING LENSES

by

Richard Muisener

and

Herbert Mosse

EXPRESS MAIL MAILING LABEL	
NUMBER	EV 414834685 US
DATE OF DEPOSIT	MARCH 2, 2004

25371315.1

BACKGROUND OF THE INVENTION

A. Field of the Invention

The invention relates generally to methods of coating lenses. More particularly, the invention relates to methods of applying polarized coatings to curved lenses.

B. Description of Related Art

Polarized lenses block light of certain polarization states. By blocking horizontally polarized light, a polarized lens reduces glare that would otherwise exist through a non-polarized lens, such as glare off water, roads, and other objects. As a result of the reduced glare, objects become more distinct and true colors more clear. There are currently several different known systems for polarizing lenses for use in eyewear.

1. Film-based polarizing systems

Current eyewear products can be fabricated by casting polyvinylalcohol-iodine films into a thermoset lens or by insert injection molding of a laminated polarized film to a thermoplastic lens. From a business perspective, these technologies are rigid and usually specific to mass production rather than made-to-order prescription ophthalmic lenses. The final optical properties of the resulting lens are determined by the film and are not easily altered. Additionally, film-based lenses require a separate inventory of polarized products, which can lead to increased costs.

Film-based products suffer from certain performance/technology shortcomings. Although the films have very high polarization efficiencies, the performance of the resulting lens is highly dependent upon the precise placement of the film within the lens. For example, if the polarization axis is not placed within three (3) degrees of the optic axis of a progress lens, the product is not acceptable. Also, a film placed on a progressive lens can greatly limit the final thickness of a wearer's lens due to the film's thickness. Furthermore, the precursor film to the polarization film can have cosmetic impurities/non-uniformities due to the nature of dying the polarization film (also known in the art as stretch films). Such non-uniformity, which can be observed as streaking in

the film's coloration, can be exacerbated by the casting process, during which a thermal or chemical attack of the film can lead to dye bleach or further color non-uniformity.

2. Other polarizing systems

Examples of lenses that have been polarized using a coating rather than film are shown in U.S. Patent Nos. 4,648,925; 4,683,153; 4,865,668; and 4,977,028. Performance of the methods disclosed in these patents involves rubbing or scratching the lens prior to deposition of the dye used to form the coating. Such a process, commercially, is "dirty" and not readily adaptable or necessarily compatible with all lens materials and curvatures. To orient a dye molecule in these processes, the substrate must be scratched to form grooves of appropriate dimensions, which will in turn create a molecular orientation of the applied die that is favorable to alignment. The overall performance (contrast ratio = 40) of such polarized lenses is relatively low. The scratching is also likely to induce some haze in the final product.

U.S. Patent No. 2,400,877 (the '877 patent) discloses treating a substrate in some manner to produce an orientation that will, in turn, properly orient the polarizable materials that are applied to the substrate to form a polarized coating. Rubbing the surface of the substrate is disclosed as the preferred means of creating the appropriate surface orientation, although static electrical and magnetic fields are also disclosed for the same purpose. The '877 patent mentions "spraying, flowing, pouring [and] brushing" as means of applying the disclosed films of polarizing materials to a surface. Dip coating is disclosed as one example of the disclosed application methods. Much of the patent is directed to describing means of fixing the applied polarized material, such as by controlling the evaporation and/or solidification of the film after it has been applied. The '877 patent states that "[a]nother object of [the] invention is to provide polarizing films on curved and intricate surfaces and to provide films in any of unlimited colors and color combinations." The patent also recites treating "polarizing filters for optical work of various kinds including photography, binoculars, goggles, windshields, mirrors, etc. . . . [and] lenses corrected for chromatic aberration . . . ." The patent does not suggest coating a lens by shear flow with a flexible apparatus or otherwise coating a surface that is not

first treated for orientation in some way. The patent also does not suggest utilizing shear flow alone in coating a surface with a polarizing liquid.

Two systems have recently been proposed to form polarized coatings on flat surfaces using shear. The Optiva systems disclosed in U.S. Patent Nos. 5,739,296; 6,049,428; and 6,174,394 include a blend of three self-assembling lyotropic liquid crystal dyes that, upon application of shear, orient to form various colored polarizers. These patents mention the use of coating rods, slot-dye (extrusion) coating, coating by capillary forces, and other methods as ways of coating a flat surface with, for example, a polymeric film or glass sheets. Because the orientation of the molecules occurs during the coating process, no surface preparation steps, such as rubbing, are necessary. This reduces the need for a specific alignment layer or reduces the incompatibility of surfaces on which liquid crystalline materials are not likely to align during application. The processes in these patents are suited to web coating a continuous roll of thin, flat polymeric films. They are not suited to use on non-flat surfaces.

U.S. Patent No. 6,245,399 discloses a liquid crystal guest-host system that is aligned by shear forces. In this patent, the dye is not directly aligned by the shear flow. Instead, the orientation of the guest dichroic (pleochroic) dye is controlled by the host lyotropic liquid crystal material, which is oriented by shear flow. This patent does not suggest any shear flow application for a non-planar surface.

SUMMARY OF THE INVENTION

The inventors have developed manners in which to apply polarizing liquids to curved surfaces, including those that have not previously been treated to create an orientation for the polarized coating, and thereafter form polarized coatings. A major benefit afforded by the present methods is that polarized coatings may now be created on made-to-order prescription lenses (*e.g.*, ophthalmic lenses) in a short amount of time. As a result, custom lens makers may now create polarized coatings for their customers on demand, without needing to retain a separate inventory of polarized products.

In one embodiment, there is provided a method comprising: providing a lens having a curved surface and applying a polarizing liquid to at least a portion of the curved surface by shear flow with a flexible apparatus.

Another aspect of the present invention provides an ophthalmic lens comprising a coating, the coating comprising a polarizing liquid, wherein the coating is applied at least by any of the methods disclosed throughout this specification.

In still another embodiment, there is provided an apparatus comprising a flexible portion, wherein the flexible portion is configured to dispose a coating onto a convex portion of a lens by shear flow. The flexible portion may be a flexible rod.

There is also provided an apparatus comprising: an ophthalmic lens having a convex surface and a polarized coating disposed on the convex surface, the polarized coating including a material that forms a polarized coating following shear flow of the material over the convex surface. The polarized coating may include a lyotropic liquid crystal material. The ophthalmic lens may include one or more layers disposed on the convex surface.

The polarizing liquid may be disposed on the curved surface prior to shear flow. The polarizing liquid may disposed on the flexible apparatus prior to shear flow. The polarizing liquid may be disposed on the periphery of the flexible apparatus prior to shear flow. The lens may be placed in a lens holder. The lens holder may be any shape. In some embodiments, the lens holder includes a curved shape. The lens holder may be curved to match the radius of the curved surface of the lens. The polarizing liquid may be disposed on the lens holder between the lens and the flexible apparatus prior to shear flow. The polarizing liquid may be disposed in a substantially straight line. The shear flow may be linear shear flow. In other aspects, the linear shear flow may be high linear shear flow. In applying the polarizing liquid to the lens, the flexible apparatus may be moved across the lens in any manner. In certain aspects, the flexible apparatus is swept across the lens.

The flexible apparatus or flexible portion may be a flexible rod. The flexible rod may include a circular, rectangular, or spherical portion. Their may be a material wrapped around the flexible apparatus. The material may be used to orient the polarizing

liquid. The material may be any substance or compound that is capable of being wrapped around the flexible apparatus. In some instances, the material is malleable. In other aspects, the material is a wire. The diameter of the wire can be variable. The flexible apparatus may include a groove or may include etching. The groove or etching may be used to orient the polarizing liquid. In other embodiments, the flexible apparatus may have include a substantially smooth surface. The substantially smooth surface may be used to orient the polarizing liquid. The flexible apparatus may be movable or non-movable. The flexible apparatus may be rotatable or non-rotatable. The flexible apparatus may be configured or designed to be attached to a holder apparatus.

The holding apparatus may be adjustable in length, width, or height. The holding apparatus may include an aperture. The aperture may be configured or designed to accept the apparatus comprising a flexible portion. The holding apparatus may include a branch. The branch may be configured or designed to accept the apparatus comprising a flexible portion. The branch me be removable.

In other embodiments, the curved surface of the lens has not been treated to create an orientation prior to the coating. The portion of the lens may be coated with a material prior to the shear flow. The material may be an adhesion primer layer. The adhesion primer layer may include a coupling agent. The curved surface of the lens may be a convex surface. The lens may include a concave surface substantially opposite the convex surface. In other embodiments, a polarized coating may be formed after the shear flow.

The methods of the present invention may further include adjusting a dye in the polarizing liquid to customize a color of the polarized coating. The polarizing liquid may be cured to form a polarized coating on a portion of the lens. The polarized coating may include a contrast ratio of at least 8, 10, 12, 15, 20, 25, 30, 35, 40, 45, 50, 60, 70, 80, or more. In other embodiments, the surface of the lens has not been treated to create an orientation prior to the shear flow.

The term "substantially" means at least approaching a given state (e.g., preferably within 10% of, more preferably within 1% of, even more preferably within 0.5% of, and most preferably identical to the given state).

The use of the word "a" or "an" when used in conjunction with the term "comprising" in the claims and/or the specification may mean "one," but it is also consistent with the meaning of "one or more," "at least one," and "one or more than one."

It is contemplated that any embodiment discussed in this specification can be implemented with respect to any method or apparatus of the invention, and *vice versa*. Furthermore, apparatuses of the invention can be used to achieve methods of the invention.

Throughout this application, the term "about" is used to indicate that a value includes the standard deviation of error for the device or method being employed to determine the value.

The use of the term "or" in the claims is used to mean "and/or" unless explicitly indicated to refer to alternatives only or the alternatives are mutually exclusive, although the disclosure supports a definition that refers to only alternatives and "and/or."

As used in this specification and claim(s), the words "comprising" (and any form of comprising, such as "comprise" and "comprises"), "having" (and any form of having, such as "have" and "has"), "including" (and any form of including, such as "includes" and "include") or "containing" (and any form of containing, such as "contains" and "contain") are inclusive or open-ended and do not exclude additional, unrecited elements or method steps.

Other objects, features and advantages of the present invention will become apparent from the following detailed description. It should be understood, however, that the detailed description and the specific examples, while indicating specific embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.

BRIEF DESCRIPTION OF THE DRAWINGS

The following drawings demonstrate non-limiting aspects of the present invention. The drawings illustrate by way of example and not limitation, and they use like references to indicate similar, although not necessarily identical, elements.

FIG. 1 is a side view of a lens having a curved surface.

FIG. 2 is a perspective view of a flexible apparatus in an un-flexed state.

FIG. 3 is a perspective view of a flexible apparatus in a flexed state.

FIG. 4 is a perspective view of a holding apparatus that is configured to hold the flexible apparatus in FIG. 2 or FIG. 3.

FIG. 5 is a non-limiting embodiment of the present invention.

DESCRIPTION OF ILLUSTRATIVE EMBODIMENTS

FIG. 1 is a side view of a lens that can be coated with the methods and apparatuses of the present invention. The lens **1** includes curved surface **2** (which is a convex surface) and curved surface **3** (which is a concave surface), the two curved surfaces being oriented substantially opposite one another. The lens **1** may be an ophthalmic lens made from any suitable material, including glass, regular plastic, and polycarbonate.

FIG. 2 shows a flexible apparatus 4 that is capable of being flexed in a variety of positions and angles. In non-limiting embodiments, for example, the flexible apparatus 4 can be flexed in a concave, convex, arcuate, and/or a circular manner. In more particular aspects of the invention, the flexible apparatus can be flexed in a concave shape that substantially matches the convex surface **2** of a lens **1** such as an ophthalmic lens. In non-limiting embodiments, the flexible apparatus **4** can include a male connector **5** that can be configured to connect to a holder apparatus which can be configured to hold the flexible apparatus **4**. In other embodiments, the connector can be a female connector. As shown in **FIG. 3**, in certain aspects the flexible apparatus **4** does not include a connector.

FIG. 3 shows a flexible apparatus **4** that is in a flexed position. The illustrated embodiment includes a wire **6** that is wrapped around a portion of the flexible apparatus **4**. The wire **6** can be used, for example, to orient or align a polarizing liquid that is disposed on a lens **1**.

FIG. 4 shows a holding apparatus **7** that can be configured to hold a flexible apparatus **4**. The holding apparatus **7** can include a branch **8** that can be configured to accept a flexible apparatus **4**. The branch **8** can include an inlet **9**. In the illustrated embodiment, the inlet **9** is configured to accept the flexible apparatus **4** shown in FIG. 2. The inlet **9**, however, can be configured to accept a flexible apparatus having a variety of shapes. Non-limiting examples of shapes can include, for example, circular, rectangular, spherical, oval, or triangular shapes. In other embodiments, the holding apparatus **7** can include knobs **10**. The knobs **10** can be used, for example, to adjust the length of the holding apparatus **7**, thereby allowing the holding apparatus **7** to accept flexible apparatuses having varying shapes and/or varying lengths. In other non-limiting embodiments, the holding apparatus **7** can be adjusted by pulling the ends **11** of the holding apparatus **7** apart or pushing the ends **11** together to lengthen or shorten the length of the holding apparatus **7**.

In another non-limiting embodiment, the holding apparatus **7** does not include branches **8**. Rather, the holding apparatus **7** can be configured to accept a flexible apparatus **4** by any suitable means known to those of skill in the art. An example includes recesses in the holding apparatus **7** that are configured to accept the ends of the flexible apparatus **4**.

FIG. 5 shows a non-limiting embodiment of the present invention. The flexible apparatus **4** is positioned in the inlet **9** of the holding apparatus **7**. The lens **1** is placed on a lens holder **12**. In other non-limiting embodiments, the lens **1** can be attached or engaged to the lens holder **12** by any suitable means, including, for example, by an adhesive, by one or more notches in the lens holder **12**, by vacuum suction cups, by one or more spring-loaded clamps, or by an interlocking collar between the lens **1** and the lens holder **12**. Other suitable means known to those skilled in the art may also be used

to hold the lens **1** or used to attach the lens **1** to the lens holder **12** illustrated in **FIG. 5** or any other suitable lens holder.

A "polarizing liquid" may include any solution configured to form a polarized coating at some time after application to a lens. Polarizing liquids include, but are not limited to, polarizing systems known to form a polarized coating as a result of shear flow of the liquid over a surface. Examples of suitable polarizing liquids include lyotropic liquid crystal materials, such as those disclosed in U.S. Patent No. 6,049,428, in which the liquid crystal can be the active dye or a host in a guest-host system. One suitable polarizing liquid may be an aqueous suspension of dyes in which the color of the resulting polarized coating can be easily adjusted.

A polarized coating that may be described as a thin crystal film (TCF) polarized coating can be formed as follows. Existing dichroic dyes, that are also lyotropic liquid crystals, may be chemically modified by sulfonation. This modification will render the dye molecules amphiphilic. Both the amphiphilic nature and flat geometry of the dye molecules will lead to a self assembly, or stacking, of the dye molecules in solution, which may also be described as the polarizing liquid. The concentration of the solution will influence the structure of the resulting coating based upon the material's liquid crystal phase diagram.

The solution may be applied to a surface and sheared. The dye molecules will be aggregates in solution that will easily align through cooperative motion upon application of shear. The solution may then be cured to yield a polarized coating by drying the solution in a controlled manner. By this, the inventors mean that if the solution is dried too quickly, the water in the solution would effectively boil off, thus disrupting the structure of any resulting coating. In this same regard, if the solution is dried too slowly, the molecules in the solution that otherwise exist at a concentration and temperature range will experience an undesirable concentration change. If a moderate pace of drying is used, the orientation of the molecules in the solution will be locked in, and the molecules will not have time to reorganize into a different orientation. Exemplary drying conditions suitable for use in performance of the present methods are provided below in

the examples. After such drying, the polarized coating may be set by making an insoluble salt.

TCF polarizing liquids (which form TCF polarized coatings and which may be referred to as TCF polarizers) offer advantages over polyvinylalcohol (PVOH) or PVOH-clad polarizers, including advantages in the following categories: **haze**: because a TCF polarizer is a single component, unlike a dispersed dye in a polymer, there is little or no scattering of light; **viewing angle**: in liquid crystal display (LCD) applications, TCF polarizers provide wider viewing angles than conventional polarizers. This aspect may be particularly useful in sunwear applications; **thickness**: TCF polarized coatings can be less than a micron in thickness, versus clad polarized coatings, which are typically at least 0.2 millimeters (mm) in thickness; and **temperature stability**: unlike conventional iodine/PVOH polarized coatings, TCF polarized coatings are stable in high humidity and temperatures exceeding 200°C. TCF polarizers may also be customized by color to best suit a given application.

A result of the methods disclosed throughout the specification and claims can be a polarized lens formed from a polarizing liquid that is capable of linear orientation under shear flow. The flexible apparatus described throughout provides a suitable means of inducing shear flow (*e.g.*, through a linear shear field) across at least a portion of (and more preferably the entirety of) the exposed surface of the subject lens. Any dye(s) in the polarizing liquid can be adjusted to customize the color of the polarized coating. A polarized coating thickness of between 300 and 5000 nanometers (nm) may be produced using 2-3 milliliters (mL) of polarizing liquid for a lens that is approximately 70 millimeters (mm) in diameter.

Prior to applying the polarizing liquid to a lens, one or more adhesion primer layers, which may comprise one or more coupling agents, may be deposited on the curved surface (or the portion of the curved surface) of the lens that is coated with the polarizing liquid as detailed above. Thus, all descriptions of coating a lens or a portion of lens encompass coating both the lens surface directly (*e.g.*, no intervening coating between the lens surface and the polarizing liquid) and indirectly (*e.g.*, an intervening

coating—such as an adhesion layer—exists between the lens surface and the polarizing liquid).

A primer coating that is used for adhesion also may be used for improving the impact resistance of a finished optical article. Typical primer coatings are (meth)acrylic based coatings and polyurethane based coatings. (Meth)acrylic based coatings are, among others, disclosed in U.S. 5,015,523 (which is expressly incorporated by reference), whereas thermoplastic and crosslinked based polyurethane resin coatings are disclosed, *inter alia*, in Japanese Patents 63-141001 and 63-87223, EP 0 404 111, and U.S. 5,316,791 (which is expressly incorporated by reference).

In particular, a primer coating suited for use with embodiments of the present methods can be made from a latex composition such as a poly(meth)acrylic latex, a polyurethane latex or a polyester latex. Among the preferred (meth)acrylic based primer coating compositions are polyethyleneglycol(meth)acrylate based compositions such as, for example, tetraethyleneglycoldiacrylate, polyethyleneglycol (200) diacrylate, polyethyleneglycol (400) diacrylate, polyethyleneglycol (600) di(meth)acrylate, as well as urethane (meth)acrylates and mixtures thereof. Preferably, a primer coating suited for use with the present methods has a glass transition temperature (Tg) of less than 30°C.

Among the preferred primer coating compositions are the acrylic latex commercialized under the name ACRYLIC LATEX A-639 (commercialized by ZENECA) and polyurethane latex commercialized under the names of W-240 and W-234 by BAXENDEN.

In a preferred embodiment, a suitable primer coating also may include an effective amount of a coupling agent in order to promote adhesion of the primer coating to the optical substrate and/or to the polarizing layer.

A primer coating composition can be applied using any classical method such as spin, dip, or flow coating. Depending upon the nature of the adhesive and impact-resistant primer coating composition, thermal curing, UV-curing or a combination of both can be used to cure the coating.

The thickness of a primer coating useful with the present methods, after curing, typically ranges from 0.05 to 20 micrometers (μm), preferably 0.5 to 10 μm and more preferably from 0.6 to 6 μm.

A suitable coupling agent may be a pre-condensed solution of an epoxyalkoxysilane and an unsatured alkoxysilane, preferably comprising a terminal ethylenic double bond. Examples of epoxyalkoxysilanes are γ-glycidoxypropyltermethoxysilane, γ-glycidoxypropylpentamethyldisiloxane, γ-glycidoxypropylmethyldiisopropenoxysilane, (γ-glycidoxypropyl)-methyldiethoxysilane, γ-glycidoxypropylmethylethoxysilane, γ-glycidoxypropyldiisopropylethoxysilane and (γ-glycidoxypropyl)bis(trimethylsiloxy)methylsilane. The preferred epoxyalkoxysilane is (γ-glycidoxypropyl)trimethoxysilane.

The unsatured alkoxysilane can be a vinylsilane, an allylsilane, an acrylic silane or a methacrylic silane. Examples of vinylsilanes are vinyltri(2-methoxyethoxy)silane, vinyltrisisobutoxysilane, vinyltri-t-butoxysilane, vinyltriphenoxysilane, vinyltrimethoxysilane, vinyltriisopropoxysilane, vinyltriethoxysilane, vinyltriacetoxysilane, vinylmethyldiethoxysilane, vinylmethyldiacetoxysilane, vinylbis(trimethylsiloxy)silane and vinyldimethoxyethoxysilane. Examples of allylsilanes are allyltrimethoxysilane, alkyltriethoxysilane and allyltris(trimethylsiloxy)silane.

Examples of acrylic silanes are 3-acryloxypropyltris (trimethylsiloxy)silane, 3-acryloxypropyltrimethoxysilane, acryloxypropylmethyldimethoxysilane, 3-acryloxypropylmethylbis(trimethylsiloxy)silane, 3-acryloxypropyldimethylmethoxysilane, n-(3-acryloxy-2-hydroxypropyl)-3-aminopropyltriethoxysilane.

Examples of methacrylic silanes are 3-methacryloxypropyltris (vinyldimethoxysiloxy)silane, 3-methacryloxypropyltris (trimethylsiloxy)silane, 3-methacryloxypropyltris(methoxyethoxy)silane, 3-metacryloxypropyltrimethoxysilane, 3-methacryloxypropylpentamethyl disiloxane, 3-methacryloxypropylmethyldimethoxysilane, 3-methacryloxpropylmethyldiethoxysilane, 3-methacryloxypropyldimethyl methoxysilane, 3-

methacryloxypropyldimethylethoxysilane, 3-methacryloxypropenyltrimethoxysilane and 3-methacryloxypropylbis (trimethylsiloxy)methylsilane. A preferred silane is acryloxypropyltrimethoxysilane.

Preferably, the amounts of epoxyalkoxysilane(s) and unsaturated alkoxysiolane(s) used for a coupling agent preparation are such that the weight ratio:

$$R = \frac{\text{weight of epoxyalkoxysilane}}{\text{weight of unsaturated alkoxysilane}}$$ verifies the condition $0.8 \leq R \leq 1.2$.

A suitable coupling agent preferably comprises at least 50% by weight of solid material from the epoxyalkoxysilane(s) and unsaturated alkoxysilane(s) and more preferably at least 60% by weight. A suitable coupling agent preferably comprises less than 40% by weight of liquid water and/or organic solvent, more preferably less than 35% by weight.

The expression "weight of solid material from the epoxyalkoxysilanes and unsaturated alkoxysilanes" means the theoretical dry extract from those silanes that is the calculated weight of unit $Q_k\ Si\ O_{(4-K)/2}$, where:

$Q_k\ Si\ O_{(4-K)/2}$ comes from $Q_k\ Si\ R'O_{(4-k)}$;

Si R' reacts to form Si OH on hydrolysis;

K is an integer from 1 to 3 and is preferably equal to 1; and

R' is preferably an alkoxy group such as OCH_3.

The water and organic solvents referred to above come from those that have been initially added in the coupling agent composition and the water and alcohol resulting from the hydrolysis and condensation of the alkoxysilanes present in the coupling agent composition. Typically, the amount of coupling agent introduced in the primer coating composition represents 0.1 to 15% by weight of the total composition weight, preferably 1 to 10% by weight.

Preferred preparation methods for the coupling agent comprise: mixing the alkoxysilanes; hydrolysing the alkoxysilanes, preferably by addition of an acid, such as hydrochloric acid; stirring the mixture; optionally adding an organic solvent; adding one

or several catalyst(s) such as aluminum acetylacetonate; and stirring (typical duration: overnight).

Furthermore, additional coatings – such as primer coatings and/or hard coatings – may be applied to a given lens on top of a polarized coating, provided that the different coatings are chemically compatible.

Preferred scratch-resistant coatings are those made by curing a precursor composition including epoxyalkoxysilanes or a hydrolyzate thereof and a curing catalyst. Preferably the scratch resistant coatings contain at least one inorganic filler such as SiO_2 and/or metal oxides colloids. Examples of such compositions are disclosed in U.S. 4,211,823 (which is expressly incorporated by reference), WO 94/10230, and U.S. 5,015,523.

The most preferred scratch-resistant coating compositions are those comprising as the main constituents an epoxyalkoxysilane such as, for example, γ-glycidoxypropyltrimethoxysilane (GLYMO) and a dialkyldialkoxysilane such as, for example dimethyldiethoxysilane (DMDES), colloidal silica and a catalytic amount of a curing catalyst such as aluminum acetylacetonate or a hydrolyzate thereof, the remainder of the composition being essentially comprised of solvents typically used for formulating these compositions. Suitable scratch-resistant coating compositions also may contain a coupling agent as described above.

For certain of the present methods, because the surface being coated is untouched by abrasives that could otherwise be used to create an orientation prior to applying the polarized coating, any visual haze that is experienced by a user of such a polarized lens should be less severe than it would be with a polarized lens that was scratched in some manner prior to the application of the polarized coating. Shear flow of the polarizing liquid across the curved lens surface should also reduce edge-effects as compared to other coating methods.

Before applying a polarizing liquid to the lens by shear flow with a flexible apparatus **4**, one option is to apply polarizing liquid by any conventional means over at least a first portion of curved surface **2**, preferably the whole curved surface of the lens **1**. Suitable conventional means for applying the polarizing liquid include dip coating, spray

coating, flow coating and spin coating. This step of applying the polarizing liquid to a first portion of the curved surface of the lens may be implemented in a separate coating apparatus, such as a dip coating apparatus or a spin coating apparatus, before shear flow.

In embodiments where the polarizing liquid already has been applied by conventional means to the curved surface of the lens, or a portion of the curved surface, it is then not mandatory to apply the polarizing liquid on the flexible apparatus **4** or on a portion of the lens holder **12** periphery between the flexible apparatus **4** and the lens **1**. Once the polarizing liquid has been applied to the curved surface of the lens **1**, and the lens **1** is placed in the lens holder **12**, the sweeping of the flexible apparatus **4** across the lens **1** will induce the shear flow and the final orientation for obtaining the polarized coating.

* * *

The following examples are included to demonstrate specific, non-limiting embodiments of the present methods. It should be appreciated by those of skill in the art that the techniques disclosed in the following examples represent techniques discovered by the inventors to function in the practice of certain methods of the invention, and thus constitute modes for its practice. However, those of skill in the art should, in light of this disclosure, appreciate that changes can be made to the techniques and materials of the following examples and still obtain like or similar results without departing from the scope of the invention.

EXAMPLES

Example 1
(Materials and Methods)

Flexible Apparatus: In one embodiment of the invention, the flexible apparatus 4 can be made from plastic tubing material. Typical flexible apparatuses had a length of 170 mm of which 105 mm is wrapped with the wire **6**. The tubing was wrapped with 100 micron diameter stainless steel Cobra cut Ø0,10mm wire from AGIECUT. The plastic tubing can be hard vacuum tubing or flexible "Tygon" tubing. The Tygon tubing used in

this experiment had an overall diameter of 7 mm with a wall thickness of 1 mm. In preferred embodiments, the tubing was clear flexible tubing (tubing polyvinyl 1/4OD x 3/16ID Parker #PV403-1).

Lens Holder: The lens holder **12** used was a 6 base aluminized hollow half-sphere. The crown of the sphere was remove so that a 6-base plano ORMA lens would form a smooth "flush" curve.

Dye application: To permit complete coverage of the lens, the lens was placed in a holder that had a curvature to match the radius of curvature of the lens. FIG. 5 shows a flexible apparatus **4** and a lens **1** on a lens holder **12**. An aliquot (1-2 mL) of Optiva N015 ink was placed on the periphery of the metal lens holder in a substantially straight line between the lens and the flexible rod. Gentle pressure was applied normal to the sphere. The rod was swept across the lens. The sweep takes place in ~1-2 seconds. The ink was allowed to dry over 1-3 minutes in a humid atmosphere (70% RH). The lenses was then removed from the holder and the ink was fixed by a BaCl (10wt%) aqueous solution. The lens can then be hardcoated as described previously. The samples in Table 1 did not possess a hardcoat.

Example 2
(Results)

Table 1

SAMPLE	DYE*	ALIGNMENT METHOD	CONTRAST RATIO
1	TCF No. 15.05.115 from Optiva	Flexible rod	30.64
2	TCF No. 15.05.115 from Optiva	Flexible rod	36.08
3	TCF No. 15.05.115 from Optiva	Flexible rod	25.06
4	TCF No. 15.05.115 from Optiva	Flexible rod	44.63
5	TCF No. 15.05.115 from Optiva	Flexible rod	36.99
6	TCF No. 15.05.115 mechanical grade from Optiva	Flexible rod	63.81
7	TCF No. 15.05.115 mechanical grade from Optiva	Flexible rod	71.44
8	TCF No. 15.05.115 mechanical grade from Optiva	Flexible rod	72.24
9	TCF No. 15.05.115 mechanical grade from Optiva	Flexible rod	51.62
10	TCF No. 15.05.115 mechanical grade from Optiva	Flexible rod	66.65

*TCF No. 15.05.115 and TCF No. 15.05.115 mechanical grade are dye solutions (11.5%) of 3 dyes in water.

The contrast ratio is the ratio of luminous transmittance between parallel and perpendicular positions. The transmission measurements were performed on a Lamda

900 spectrometer in a spectral range of 380 – 780 nm using a reference polarizer in the beam path. The photopic response was calculated based upon the full spectral scan. The perpendicular position was found by rotating the lens with respect to the reference polarizer until a minimum transmission was observed at 550 nm. A full spectral scan was performed at this position and upon rotating the lens 90 degrees.

* * *

It should be understood that the present methods and apparatuses are not intended to be limited to the particular forms disclosed. Rather, they are to cover all modifications, equivalents, and alternatives falling within the scope of the claims. For example, while polarized coatings having contrast ratios of about 25 and higher have been described, suitable polarized coatings formed according to the present methods may have contrast ratios as low as 8 (according to ISO 8980-3). The claims are not to be interpreted as including means-plus- or step-plus-function limitations, unless such a limitation is explicitly recited in a given claim using the phrase(s) "means for" or "step for," respectively.

REFERENCES

The following references, to the extent that they provide exemplary procedural or other details supplementary, are specifically incorporated by reference.

U.S. Patent 2,400,877

U.S. Patent 4,211,823

U.S. Patent 4,648,925

U.S. Patent 4,683,153

U.S. Patent 4,865,668

U.S. Patent 4,977,028

U.S. Patent 5,015,523

U.S. Patent 5,316,791

U.S. Patent 5,739,296

U.S. Patent 6,049,428

U.S. Patent 6,174,394

U.S. Patent 6,245,399

PCT Appln. WO 94/10230

Japanese Pat. 63-141001

Japanese Pat. 63-87223

European Pat. 0 404 111

WHAT IS CLAIMED:

1. A method comprising:

   (a) providing a lens having a curved surface; and

   (b) applying a polarizing liquid to at least a portion of the curved surface by shear flow with a flexible apparatus.

2. The method of claim 1, wherein the polarizing liquid is disposed on the curved surface prior to shear flow.

3. The method of claim 1, wherein the polarizing liquid is disposed on the flexible apparatus prior to shear flow.

4. The method of claim 3, wherein the polarizing liquid is disposed on the periphery of the flexible apparatus.

5. The method of claim 1, wherein the lens is placed in a lens holder.

6. The method of claim 5, wherein the lens holder is curved.

7. The method of claim 6, wherein the lens holder is curved to match the radius of the curved surface of the lens.

8. The method of claim 5, wherein the polarizing liquid is disposed on the lens holder between the lens and the flexible apparatus prior to shear flow.

9. The method of claim 8, wherein the polarizing liquid is disposed in a substantially straight line.

10. The method of claim 1, wherein the shear flow is linear shear flow.

11. The method of claim 10, wherein the linear shear flow is high linear shear flow.

12. The method of claim 1, wherein the flexible apparatus is swept across the lens.

13. The method of claim 1, wherein the flexible apparatus is a flexible rod.

14. The method of claim 1, wherein the flexible apparatus comprises a circular, rectangular, or spherical portion.

15. The method of claim 1, wherein a material is wrapped around the flexible apparatus.

16. The method of claim 15, wherein the material is a wire.

17. The method of claim 1, wherein the flexible apparatus comprises a groove.

18. The method of claim 1, wherein the flexible apparatus comprises etching.

19. The method of claim 1, wherein the flexible apparatus comprises a substantially smooth surface.

20. The method of claim 1, wherein the flexible apparatus is rotatable.

21. The method of claim 1, wherein the flexible apparatus is not rotatable.

22. The method of claim 1, wherein the flexible apparatus is configured to be attached to a holder apparatus.

23. The method of claim 1, wherein the curved surface has not been treated to create an orientation prior to the coating.

24. The method of claim 1, wherein the portion is coated with a material prior to the shear flow.

25. The method of claim 24, wherein the material is an adhesion primer layer.

26. The method of claim 25, wherein the adhesion primer layer comprises a coupling agent.

27. The method of claim 1, wherein the curved surface is a convex surface, and the lens has a concave surface substantially opposite the convex surface.

28. The method of claim 1, wherein a polarized coating is formed after the shear flow.

29. The method of claim 1, further comprising adjusting a dye in the polarizing liquid to customize a color of the polarized coating.

30. The method of claim 1, further comprising curing the polarizing liquid to form a polarized coating on the portion, the polarized coating having a contrast ratio of at least 8.

31. The method of claim 30, wherein the polarized coating has a contrast ratio of at least 30.

32. The method of claim 30, wherein the polarized coating has a contrast ratio of at least 50.

33. The method of claim 1, wherein the surface has not been treated to create an orientation prior to the shear flow.

34. An ophthalmic lens comprising a coating, the coating comprising a polarizing liquid, wherein the coating is applied at least by the method of claim 1.

35. An apparatus comprising a flexible portion, wherein the flexible portion is configured to dispose a coating onto a convex portion of a lens by shear flow.

36. The apparatus of claim 35, wherein the flexible portion is a flexible rod.

37. The apparatus of claim 35, wherein the flexible portion comprises a circular, rectangular, or spherical portion.

38. The apparatus of claim 35, wherein a material is wrapped around the flexible portion.

39. The apparatus of claim 38, wherein the material is a wire.

40. The apparatus of claim 35, wherein the flexible portion comprises a groove.

41. The apparatus of claim 35, wherein the flexible portion comprises etching.

42. The apparatus of claim 35, wherein the flexible portion comprises a substantially smooth surface.

43. The apparatus of claim 35, wherein the flexible portion is rotatable.

44. The apparatus of claim 35, wherein the flexible portion is not rotatable.

45. The apparatus of claim 35, wherein the apparatus is configured to be attached to a holding apparatus.

46. The apparatus of claim 45, wherein the holding apparatus is adjustable in length or width.

47. The apparatus of claim 45, wherein the holding apparatus comprises an aperture.

48. The apparatus of claim 47, wherein the aperture is configured to accept the apparatus comprising a flexible portion.

49. The apparatus of claim 45, wherein the holding apparatus comprises a branch.

50. The apparatus of claim 49, wherein the branch is configured to accept the apparatus comprising a flexible portion.

51. The apparatus of claim 49, wherein the branch is removable.

52. An apparatus comprising:

(a) an ophthalmic lens having a convex surface; and

(b) a polarized coating disposed on the convex surface, the polarized coating including a material that forms a polarized coating following shear flow of the material over the convex surface.

53. The apparatus of claim 52, wherein the polarized coating includes lyotropic liquid crystal material.

54. The apparatus of claim 52, further comprising one or more layers disposed on the convex surface.

ABSTRACT

Methods and apparatuses for coating at least a portion of a curved surface of a lens with a polarizing liquid are disclosed throughout the specification. For example, there is provided a method comprising providing a lens having a curved surface, and applying a polarizing liquid to at least a portion of the curved surface by shear flow with a flexible apparatus. Other methods are included. Apparatuses include ophthalmic lenses having polarized coatings formed according to any of the disclosed methods.

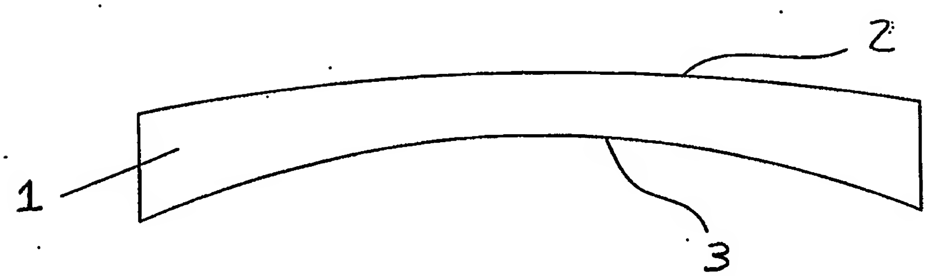

FIG. 1

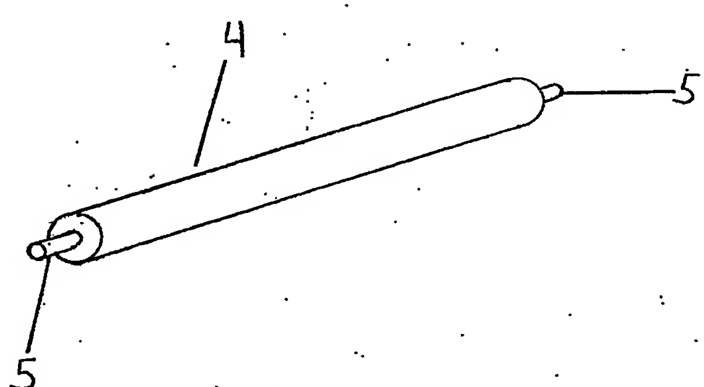

FIG. 2

Dkt. No: ESOA:009USP1 Customer No.: 32425
Inventor: Richard Muisener et al.
Title: Methods for coating Lenses
Filed: March 2, 2004

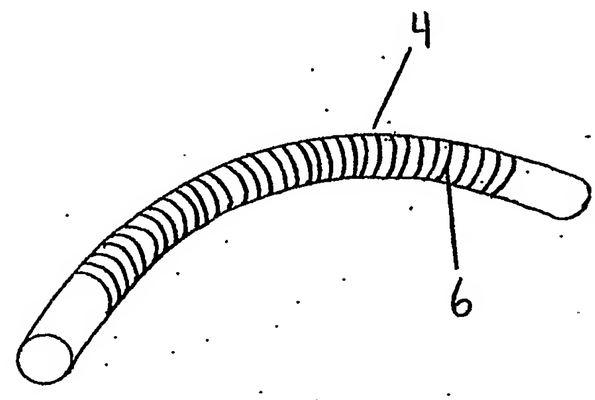

FIG. 3

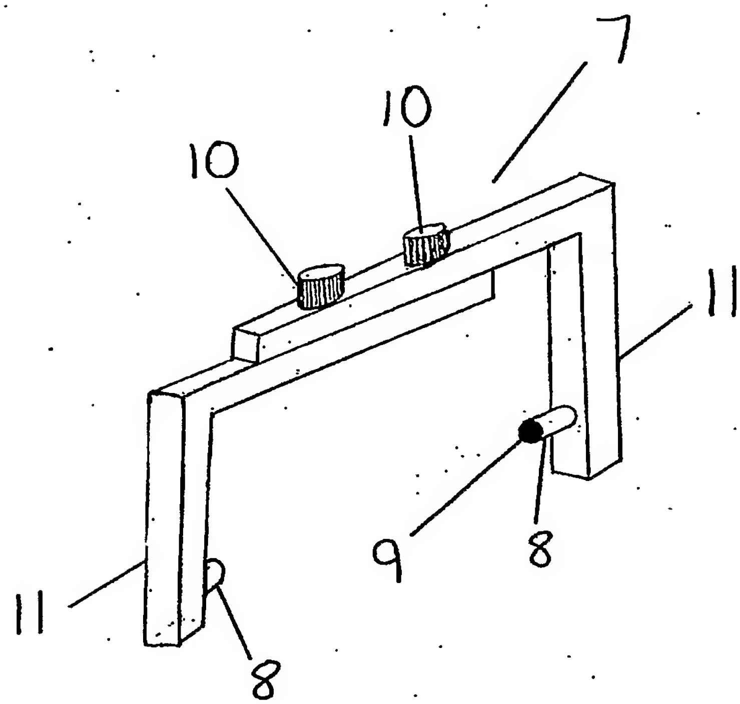

FIG. 4

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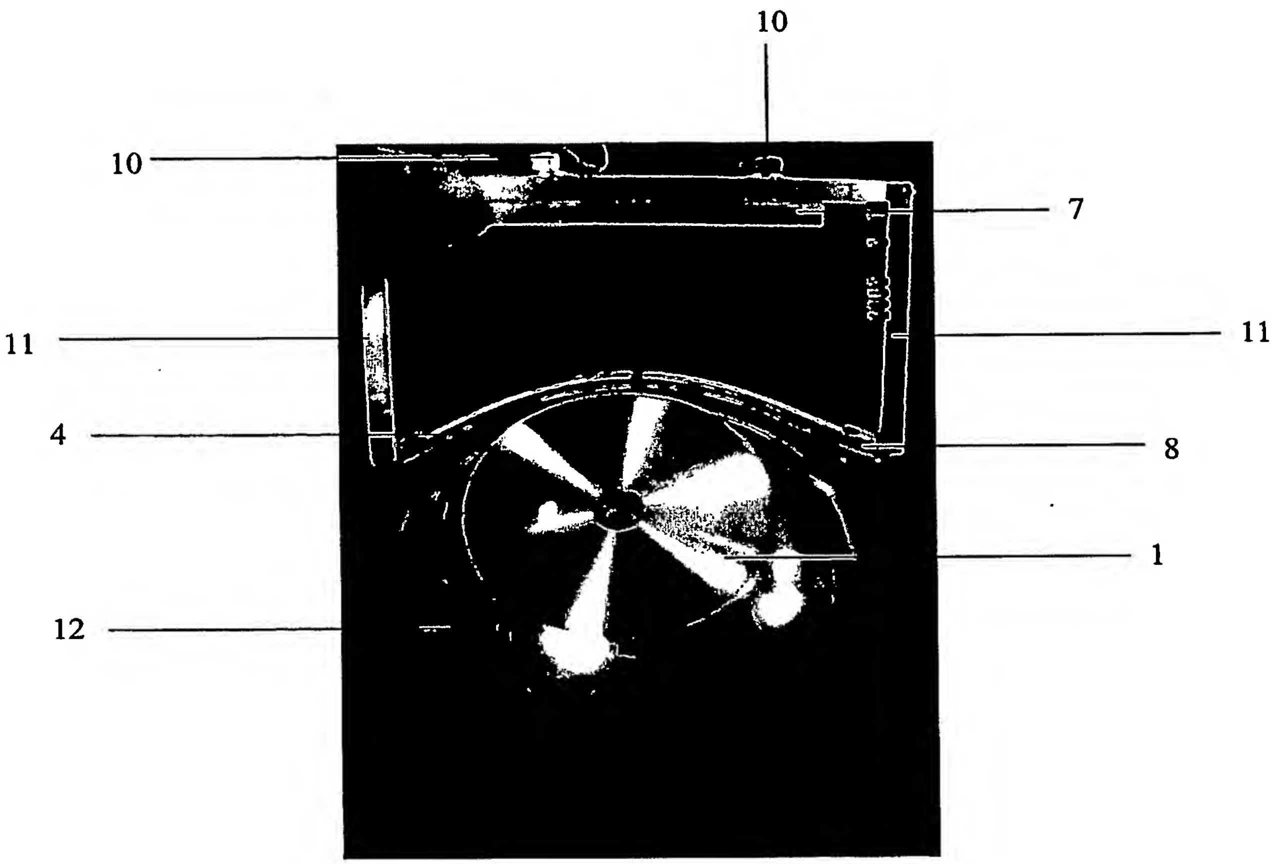

FIG. 5